A posteriori adjustment of near-term climate predictions: Accounting for the drift dependence on the initial conditions

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- Initializing dynamic climate predictions from observations induces a model drift

⇒ How to best correct it?

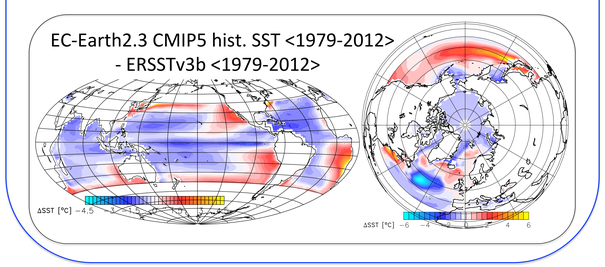
→ We propose new method to account for the dependence of the drift on the initial state of prediction

→ Principle: linear regression of the model error at a given forecast time on IC (smoothed in time)

The impact of new method is examined on monthly means of tropical and NH high-latitude SST, and the NH sea ice extent in climate predictions with EC-Earth2.3

Coupled climate model EC-Earth2.3 (IFS + NEMO2/LIM2 + H-TESSEL)
- CMIP5 unconstrained historical simulation (using RCP4.5 forcing after 2005)
- CMIP5 5-member decadal predictions initialized on 1st of November from 1978 to 2005

Observations/analyses:
- NOAA ERSSTv3b monthly means
- NSIDC monthly sea ice extent in the NH



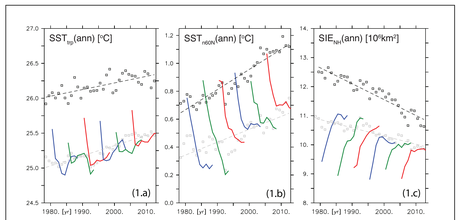


Figure 1. Annual means of (a) tropical SST averaged between 30ºS and 30ºN, (b) SST averaged north of 60ºN, and (c) the NH SIE, from 1979 to 2012, for ERSSTv3b and NSIDC observations (black squares), historical EC-Earth2.3 simulations unconstrained by OBS (HIST - grey squares), and OBS initialized EC-Earth2.3 decadal predictions (INIT - colored curves show only every 5th).

- **Bias correction method I** → MEAN (PER-PAIR) BIAS CORRECTION METHOD

$$m_{i,l} \equiv \overline{m_l} + m'_{i,l} \;\; and \;\; o_{i,l} \equiv \overline{o_l} + o'_{i,l},$$
$$m_{i,l} \longmapsto \hat{m}_{i,l} \equiv m_{i,l} - [\overline{m_l} - \overline{o_l}] = \overline{o_l} + m'_{i,l}.$$

m - "raw" forecast, o - obs/analysis, i - start date (year), l - forecast time

- **Bias correction method II** → TREND BIAS CORRECTION METHOD

$$m_{i,l} \equiv [a_l^{(m)} + b_l^{(m)} i] + m''_{i,l} \;\; and \;\; o_{i,l} \equiv [a_l^{(o)} + b_l^{(o)} i] + o''_{i,l},$$
$$m_{i,l} \longmapsto \tilde{m}_{i,l} \equiv m_{i,l} - \{[a_l^{(m)} + b_l^{(m)} i] - [a_l^{(o)} + b_l^{(o)} i]\}$$
$$= \hat{m}_{i,l} - [b_l^{(m)} - b_l^{(o)}][i - \bar{i}].$$

- **Bias correction method III** → NEW IC-BASED BIAS CORRECTION METHOD

$$m_{i,l} \equiv [\alpha_l^{(m)} + \beta_l^{(m)} o_i^{(IC)}] + m'''_{i,l} \;\; and \;\; o_{i,l} \equiv [\alpha_l^{(o)} + \beta_l^{(o)} o_i^{(IC)}] + o'''_{i,l},$$
$$m_{i,l} \longmapsto \tilde{\tilde{m}}_{i,l} \equiv m_{i,l} - \{[\alpha_l^{(m)} + \beta_l^{(m)} o_i^{(IC)}] - [\alpha_l^{(o)} + \beta_l^{(o)} o_i^{(IC)}]\}$$
$$= \hat{m}_{i,l} - [\beta_l^{(m)} - \beta_l^{(o)}][o_i^{(IC)} - \overline{o_i^{(IC)}}].$$

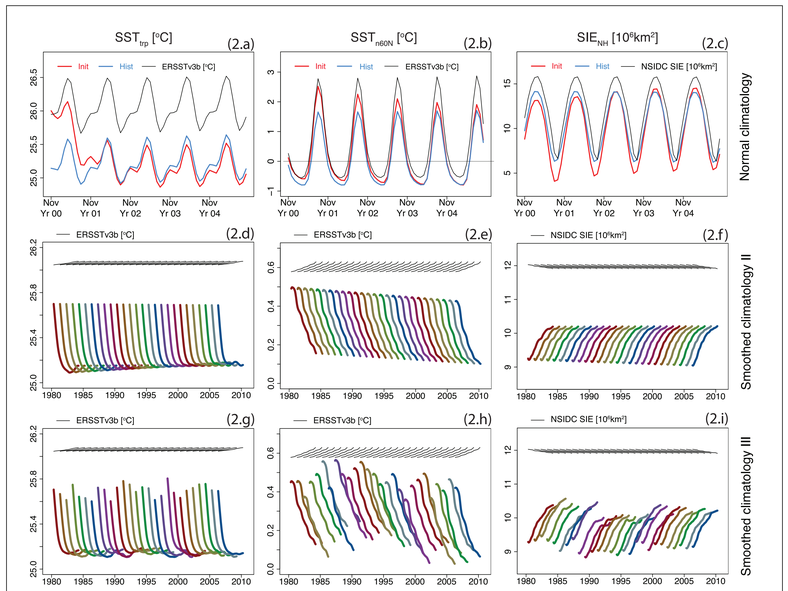


Figure 2. The left, middle and right column presents derived quantities from the monthly means of tropical SST, the SST north of 60ºN and the NH SIE, respectively. The top row shows 5 years of the development of the bias in the standard climatology (I) for the initialized predictions (INIT- red curve) that starts from the OBS (black curve) and converges to the historical simulation (HIST - blue curve). The middle and bottom row compares 12-month smoothed 5-year long climatologies of OBS (black curves) and initialized predictions (colored curves) using the bias correction method (II) and (III), respectively.

Instantaneous IC is too noisy ⇒ smoothing OBS IC in time is critical for monthly and longer-term predictions

Implemented:
$o^{(IC)}_i = o_{i,1}$

Other options:
$o^{(IC)}_i = o_{i-1}$, average from 15 days before to 15 days after IC, etc.

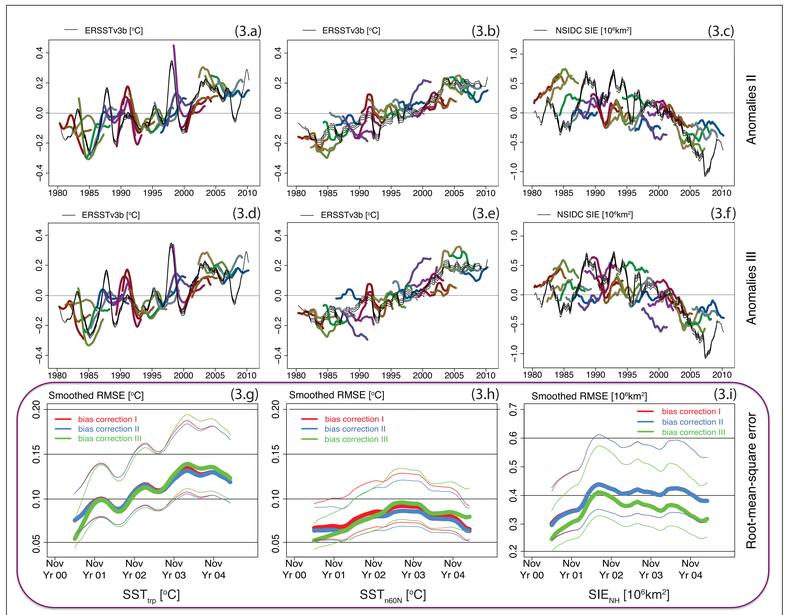


Figure 3. The left, middle and right column presents derived quantities from the monthly means of tropical SST, the SST north of 60ºN and the NH SIE, respectively. The top and middle row compares the 5-year long time series of anomalies of OBS (black curves) and initialized predictions (colored curves) using the bias correction method (II) and (III), respectively.The bottom row compares the 12-month smoothed RMSE over the 5-year prediction period for the mean bias correction adjustment (method I - red curve), the trend bias correction adjustment (method II - blue curve), and the new IC-based bias correction adjustment (method III - green curve). The colored thins curves mark the 95% confidence level based on χ^2 distribution.

→ New bias correction method for climate predictions that takes into account the conditional dependence of the drift on observed IC through a **linear regression of the model error on observed conditions in the first forecast month**

→ Improvements of new method (over the two established methods) in deterministic skill of two large-scale SST indices and the NH sea ice extent are evident from **at least in the first forecast year** (tropical SST) **up to five years** (sea ice extent)